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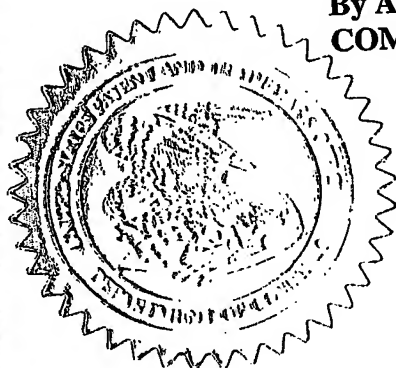
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*M. Tarver*

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# PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto				
TITLE OF THE INVENTION (500 characters max)				
PUMP MOTOR WITH BEARING PRELOAD				
Direct all correspondence to:		CORRESPONDENCE ADDRESS		
<input checked="" type="checkbox"/> Customer Number		23638		
OR		Type Customer Number here		
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ENCLOSED APPLICATION PARTS (check all that apply)				
<input checked="" type="checkbox"/> Specification Number of Pages		10	<input type="checkbox"/> CD(s), Number	
<input checked="" type="checkbox"/> Drawing(s) Number of Sheets		6	<input checked="" type="checkbox"/> Other (specify)	
<input checked="" type="checkbox"/> Application Data Sheet. See 37 CFR 1.76		Return Receipt Postcard		
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT				
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.		FILING FEE AMOUNT (\$)		
<input type="checkbox"/> A check or money order is enclosed to cover the filing fees				
<input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number:		01-0265	\$80.00	
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.				
<input checked="" type="checkbox"/> No.				
<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: _____				

Respectfully submitted,  
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Date 04/14/2003  
REGISTRATION NO. 44,764  
(if appropriate)  
Docket Number: 2974/2

## USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C. 20231.

**Initial Information Data Sheet**

Sheet 1 of 1

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**Application Information**

Title Line One:: PUMP MOTOR WITH BEARING PRELAOD  
Total Drawing Sheets:: 6  
Formal Drawings?: No  
Application Type:: Provisional

**Representative Information**

Registration Number One:: 29,037  
Registration Number Two:: 37,532  
Registration Number Three:: 44,407  
Registration Number Four:: 47,394  
Registration Number Five:: 44,764

## PUMP MOTOR WITH BEARING PRELOAD

### BACKGROUND OF THE INVENTION

[0001] This invention relates generally to electric motors and more particularly to an electric motor intended to be used with a reciprocating load such as a diaphragm pump. Electric motors often use bearings to reduce friction, particularly rolling element bearings such as ball bearings. Commercially available bearings have some clearance between their individual components, e.g. between the balls and the outer race or the inner race, thereby allowing some degree of radial and axial play. In an application where the motor is connected to a cyclic load, particularly a radial load (i.e. perpendicular to the motor shaft axis) such as that applied by a diaphragm pump, the interaction of the bearing play with the load may cause the motor life to be appreciably reduced through fatigue, fretting of the motor components, and rapid wear.

[0002] Attempts have been made to apply a preload to motor bearing assemblies to remove play. However, in operation the motor will be subject to changing internal temperatures, resulting from heat generated by the motor itself or absorbed from the environment in which the motor operates. The parts of the motor responsible for creating the bearing preload condition have differing rates of thermal expansion. This varying thermal expansion may cause the preload on the bearings to be lost, resulting in the accelerated wear described above. The varying thermal expansion may also cause an excessive axial and/or radial load to be placed on the bearings thus also accelerating wear.



[0003] Accordingly, there is a need for a motor having a consistent preload under all operating conditions.

#### BRIEF SUMMARY OF THE INVENTION

[0004] The above-mentioned need is met by the present invention, which provides a motor having bearing assemblies preloaded to remove axial and radial play therefrom. The inner and outer races of each bearing are secured to each of the components to which they are attached. The motor is constructed of components having coefficients of thermal expansion selected such that the selected preload will be retained throughout the motor's operating temperature range.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The subject matter that is regarded as the invention may be best understood by reference to the following description taken in conjunction with the accompanying drawing figures in which:

[0006] Figure 1 is a side elevational view of a ball bearing in a rest condition.

[0007] Figure 2 is a side elevational view of the ball bearing of Figure 1 in a preloaded condition.

[0008] Figure 3 is enlarged view of a portion of the bearing of Figure 2.

[0009] Figure 4 is a side elevational view of a first embodiment of a motor constructed in accordance with the present invention.

[0010] Figure 5 is a side elevational view of a first alternative arrangement of the components of the motor of Figure 4.

[0011] Figure 6 is a side elevational view of a second alternative arrangement of the components of the motor of Figure 4.

[0012] Figure 7 is a side elevational view of a third alternative arrangement of the components of the motor of Figure 4.

[0013] Figure 8 is a side elevational view of a second embodiment of a motor constructed in accordance with the present invention.

[0014] Figure 9 is a side elevational view of a first alternative arrangement of the components of the motor of Figure 8.

[0015] Figure 10 is a side elevational view of a second alternative arrangement of the components of the motor of Figure 8.

[0016] Figure 11 is a side elevational view of a third alternative arrangement of the components of the motor of Figure 8.

#### DETAILED DESCRIPTION OF THE INVENTION

[0017] Referring to the drawings wherein identical reference numerals denote the same elements throughout the various views, Figure 1 shows a schematic view of a typical ball bearing 1 including generally cylindrical, concentrically disposed inner and outer races 2 and 3. An array of balls 4 are mounted between the races. The balls 4 may be separated and located by a cage 5 as shown. The balls 4 are received in arcuate grooves 6 and 7 formed in the inner and outer races respectively. The grooves have a radius of curvature greater than the radius of the balls 4, so that when assembled the balls 4 will have a point contact with the races. Because of spacing between the various elements, the bearing 1 has a radial clearance in the direction denoted "R", and an axial clearance in the direction denoted "A". These clearances allow relative radial and axial motion between the inner race 2 and the outer race 3.

[0018] Figure 2 depicts the bearing 1 in a preloaded condition. An axial preload force is applied to the bearing 1 in the direction of arrow P. This causes the inner race 2 to shift axially with respect to the outer race 3. As shown more clearly in Figure 3, The axial motion is stopped by the interference of the balls 4 with the grooves in the inner and outer races. Additionally, because of the arcuate shape of the grooves, relative axial motion of the bearing races causes a wedging effect which prevents relative radial motion between the inner and outer races. Thus, an axial preload may be used to remove both axial and radial play from a ball bearing.

[0019] Turning now to the present invention, Figure 4 shows a first embodiment of a motor 10 constructed in accordance with the present invention. The illustrated example is of a brushless permanent magnet DC motor, but the operative principle

of the present invention is equally application to other types of motors as well. The basic components of the motor 10 are a housing 12, an end bell 14, a stator 16, a rotor assembly 18, a front bearing 20, a rear bearing 22, and a spring 24. The housing 12 is a generally cylindrical, open-ended member including an axially extending portion 26 and a front end plate 28 which has a front bearing pocket 30 formed therein. The front end plate portion of the housing 12 could also be a separate component attached by a variety of methods, for example, screws, press fit, welding, etc. The housing 12 may be formed by any known method including casting, forging, machining, powder metallurgy, etc. The end bell 14 is a member adapted to close off the rear end of the housing 12 and is attached to the rear end of the housing 12, for example by the machine screws 32 shown in Figure 4. The end bell 14 has a rear bearing pocket 34 formed therein. The stator 16 is of a known type comprising an array of flat plates wound with coils of wire. The rotor assembly 18 comprises a shaft 36 having a central portion 38, an axially extending front shaft extension 40, and an axially extending rear shaft extension 42. A plurality of permanent magnets 44 are secured to the outer surface of the central portion, for example with an adhesive. The front bearing 20 is of a known rolling-element type such as a ball bearing. Its outer race 46 is received in the front bearing pocket 30, and its inner race 48 receives the front shaft extension 40 of the rotor assembly 18. The rear bearing 22 is also of a known rolling-element type such as a ball bearing. Its outer race 50 is received in the rear bearing pocket 34, and its inner race 52 receives a portion of the rear shaft extension 42. In the illustrated example the spring is a compression-type coil spring. However, the spring 24 may be of any type which fits in the space provided for it and which provides the required preload force. A belleville spring washer could be used, for example.

[0020] The motor 10 is assembled so that a preload is applied to the bearings 20 and 22 which removes all axial and radial play in each bearing as described above. The preload is applied such that the inner races of the bearings are axially biased in opposite directions. An exemplary assembly sequence is as follows. The rear bearing 22 is assembled to the end bell 14. The outer race 50 of the rear bearing 22

is secured to the end bell 14 so that it cannot move relative to the end bell 14, for example by press fit, adhesive, tack welding, brazing, or the like. The front bearing 20 is then assembled to the housing 12. The outer race 46 of the front bearing 20 is secured to the housing 12 so that it cannot move relative to the housing 12, in a manner similar to the rear bearing 22.

[0021] The spring 24 is then assembled to the front shaft extension 40 of the rotor assembly 18, and the rotor assembly 18 is then inserted in the housing 12. One end of the spring 24 bears against the inner race 48 of the front bearing 20 and the other end of the spring 24 bears against the central portion 38 of the rotor assembly 18. The end bell 14 is subsequently attached to the housing 12 which places the rear shaft extension 42 into the inner race 52 of the rear bearing 22. The action of the compressed spring 24 forces the inner races of each bearing outward into a condition where all axial and radial play is eliminated. This creates a preload force of a magnitude determined by the characteristics of the spring 24.

[0022] Finally, the inner race 48 of the front bearing 20 is secured to the front shaft extension 40, and the inner race 52 of the rear bearing 22 is secured to rear shaft extension 42, so that no relative motion can take place between either of the inner races and the rotor assembly 18. The inner races may be secured to the rotor assembly 18 by a variety of methods, as described above. Thus, the components of the motor 10 are secured in a position which maintains the preload created by the spring 24 during the assembly process. The arrangement eliminates all axial and radial play from the bearings and shaft.

[0023] Figure 5 illustrates a motor 110 which is a variation of the motor 10 depicted in Figure 4. In this instance, the spring 24 is placed over the rear shaft extension 42 of the rotor assembly 18, between the central portion 38 of the shaft 36 and the inner race 52 of the rear bearing 22. The assembly and operation of the motor 110 is otherwise similar to that of the example illustrated in Figure 4 and described above.

[0024] Figure 6 illustrates another variation 210 of the motor 10. The construction is again generally similar to that illustrated in Figure 4, above, the



primary difference being that the spring 24 bears on the outer race of the bearings, as described in detail below.

[0025] Assembly of the motor 210 starts with the front bearing 20 being assembled to the housing 12. The outer race 46 of the front bearing 20 is secured to the housing 12 so that it cannot move relative to the housing 12, for example by press fit, adhesive, tack welding, brazing, or the like. The rotor assembly 18 is assembled to the housing 12. The inner race 48 of the front bearing 20 is secured to the front shaft extension 40 so that it cannot move relative to the front shaft extension 40.

The rear bearing 22 is then assembled to the rotor assembly 18. The inner race 52 of the rear bearing 22 is secured to the rear shaft extension so it cannot move relative to the rear shaft extension. The spring 24 is assembled to the end bell 14, being inserted in the rear bearing pocket. The end bell 14 is then assembled to the housing 12 which inserts the rear bearing 22 into the end bell 14. The spring 24 thus mates between the end bell 14 and the outer race 50 of the rear bearing 22.

[0026] The action of the compressed spring 24 forces the inner races of each bearing outward into a condition where all axial and radial play is eliminated. This creates a preload force of a magnitude determined by the characteristics of the spring 24.

[0027] Finally, the outer race 50 of the rear bearing 22 is secured to the end bell 14, so that no relative motion can take place between the outer race 50 and the end bell 14. The outer race 50 may be secured to the end bell 14 by a variety of methods, as described above. Thus, the components of the motor 210 are secured in a position which maintains the preload provided by the spring 24 during the assembly process. This arrangement eliminates all axial and radial play from the bearing/shaft mechanism.

Figure 7 illustrates a variation 310 of the motor 210. In this instance, the spring 24 is placed over the front shaft extension 40 of the rotor assembly 18, between the housing 12 and the outer race 50 of the rear bearing 22. The assembly and

operation of this variation is otherwise similar to that of the example illustrated in Figure 6 and described above.

[0028] Figure 8 shows a second embodiment of a motor 410 constructed in accordance with the present invention. This type of motor is sometimes referred to as a cantilevered design because of the relationship of the rotor assembly to the bearings. The basic components of the motor 410 are a housing 12, a stator 16, a rotor assembly 18, a front bearing 20, a rear bearing 22, and a preload spring 24. The housing 12 is a generally cylindrical, open-ended member including outer axially extending portion 26, an inner axially extending portion 27, and a front end plate 28. The inner axially extending portion 27 defines a front bearing pocket 30 and a rear bearing pocket 34. The housing 12 may be formed by any known method including casting, forging, machining, powder metallurgy, etc. The stator 16 is of a known type comprising an array of flat plates wound with coils of wire. The rotor assembly 18 comprises a shaft 36, a magnet hub 37 attached to the rear end of the shaft 36, and a plurality of permanent magnets 44 secured to the outer surface of the magnet hub 37, for example with an adhesive. The front bearing 20 is of a known rolling-element type such as a ball bearing. Its outer race 46 is received in the front bearing pocket 30, and its inner race 48 receives the front shaft extension 40 of the rotor assembly 18. The rear bearing 22 is also of a known rolling-element type such as a ball bearing. Its outer race 50 is received in the rear bearing pocket 34, and its inner race 52 receives a portion of the shaft 36. In the illustrated example the spring is a compression-type coil spring. However, the spring 24 may be of any type which fits in the space provided for it and which provides the required preload force. A belleville spring washer could be used, for example.

[0029] The motor 410 is assembled so that a preload is applied to the bearings 20 and 22 which removes all axial and radial play in each bearing as described above. The preload is applied such that the bearings are axially biased in opposite directions. An exemplary assembly sequence is as follows. First, the spring 24 is assembled to the rotor assembly 18. The rear bearing 22 is assembled to the housing 12. The outer race 50 of the rear bearing 22 is secured to the housing 12.

so that no relative motion can take place between the outer race 50 and the housing 12, for example by press fit, tack welding, brazing, adhesive, etc.

The front bearing 20 is assembled to the housing 12. The outer race 46 of the front bearing 20 is secured to the housing 12 so that no relative motion can take place between the outer race 46 and the housing 12.

Next, the rotor assembly 18 is assembled to the housing 12, placing the shaft 36 into the inner races of each bearing. A lock ring 54 is then assembled to the front end of the shaft 36. This compresses the spring 24. The action of the compressed spring 24 forces the inner races of each bearing inward into a condition where all axial and radial play is eliminated. This creates a preload force of a magnitude determined by the characteristics of the spring 24.

Finally, the inner races of both the front bearing 20 and the rear bearing are secured to the shaft 36 so that no relative motion can take place between the inner races and the shaft 36, in a manner described above. This arrangement eliminates all axial and radial play from the bearing and shaft mechanism.

[0030] Figure 9 illustrates a motor 510 which is a variation of the motor 410 depicted in Figure 8. In this instance, the spring 24 is placed over the front end of the shaft 36 between the lock ring 54 and the inner race 48 of the front bearing 20. The assembly and operation of the motor 510 is otherwise similar to that of the example illustrated in Figure 8 and described above.

[0031] Figure 10 illustrates another variation 610 of the motor 410. The construction is again generally similar to that illustrated in Figure 8 above, the primary difference being that the spring 24 bears on the outer race of the bearings, as described in detail below.

[0032] First, the spring 24 is assembled to the housing 12. The rear bearing 22 is then assembled to the rotor assembly 18. The inner race 52 of the rear bearing 22 is secured to the shaft so that no relative motion can take place between the inner race 52 and the shaft 36, for example by press fit, tack welding, brazing, adhesive, etc.

[0033] The front bearing 20 is assembled to the housing 12. The outer race 46 of the front bearing is secured to the housing 12 so that no relative motion can take place between the outer race 46 and the housing 12, in a manner described above.

[0034] The rotor assembly 18 is assembled to the housing 12. This places the shaft 36 into the inner race 48 of the front bearing 20. A lock ring 54 is then assembled to the shaft 36. This compresses the spring 24. The action of the compressed spring 24 forces the inner races of each bearing inward into a condition where all axial and radial play is eliminated. This creates a preload force of a magnitude determined by the characteristics of the spring 24.

[0035] Finally, the inner race of the front bearing 20 is secured to the shaft 36 and the outer race 50 of the rear bearing 22 is secured to the housing 12 so that no relative motion can take place between these components, in a manner described above. This arrangement eliminates all axial and radial play from the bearing and shaft mechanism.

[0036] Figure 11 illustrates a motor 710 which is a variation of the motor 610 depicted in Figure 10. In this instance, the spring 24 is placed over the front end of the shaft 36 between end of the front bearing pocket 30 and the outer race 46 of the front bearing 20. The assembly and operation of the motor 710 is otherwise similar to that of the example illustrated in Figure 10 and described above.

[0037] While several basic configurations and methods of assembly have been described above, it is noted that the specific configuration or assembly sequence is not critical to the present invention. Rather, it is important that a preload be applied to remove axial and radial play from the rotor and bearing assemblies, and that the inner and outer race of each of the bearings be secured such that no relative motion can take place between the race and the mating component. Furthermore, a preload must be maintained over the motor's operating temperature range adequate to preserve a zero-play condition in the axial and radial directions, under the expected loads. This is accomplished by the selection of materials used for the housing, rotor assembly, and bearings based on their coefficients of thermal expansion. The difference in coefficients of thermal expansion of the various

components is minimized. Furthermore, the absolute value of the coefficient of linear thermal expansion of each component is minimized, because even if all of the components are of the same material, excessive thermal expansion will cause loss of the bearing preload if the coefficient of linear thermal expansion is too high. Examples of materials which are known to exceed the required coefficient of linear thermal expansion include brass, zinc, and aluminum.

[0038] An example of a suitable combination of materials is as follows. The bearings may be made of a stainless steel alloy such as high carbon chromium steel, JIS G4805/SUJ2. This is consistent with the alloys used in commercially available ball bearings, and provides a baseline for the coefficient of linear thermal expansion to be matched by the other motor components. Accordingly, the housing, shaft and end bell may be made from a stainless steel alloy, such as a 400-series alloy. Alternatively, some of these parts could be made from a low-carbon steel. This combination of materials will preserve an adequate preload over the operating temperature of a typical motor, for example from about  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ ) to about  $105^{\circ}\text{C}$  ( $220^{\circ}\text{F}$ ).

[0039] The foregoing has described a motor assembly for use with a reciprocating load such as a diaphragm pump. While specific embodiments of the present invention have been described, it will be apparent to those skilled in the art that various modifications thereto can be made without departing from the spirit and scope of the invention. Accordingly, the foregoing description of the preferred embodiment of the invention and the best mode for practicing the invention are provided for the purpose of illustration only and not for the purpose of limitation.

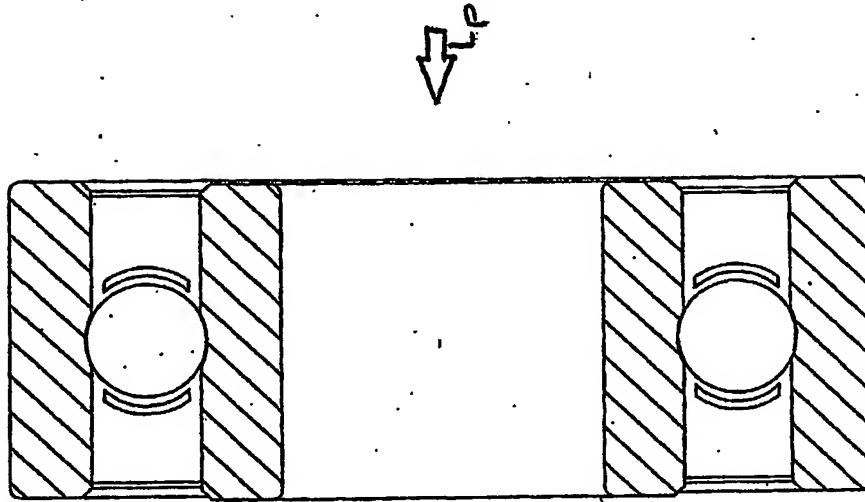


FIG. 2

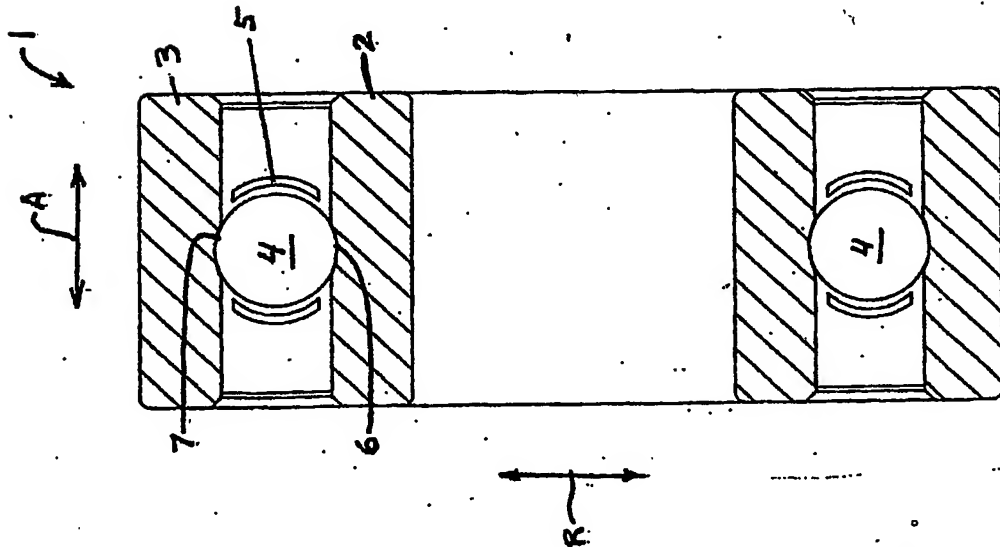


FIG. 1

Title: PUMP MOTOR WITH BEARING PRELOAD  
 Inventor's Name: Hargraves et. al.  
 Pocket No: 2974/2  
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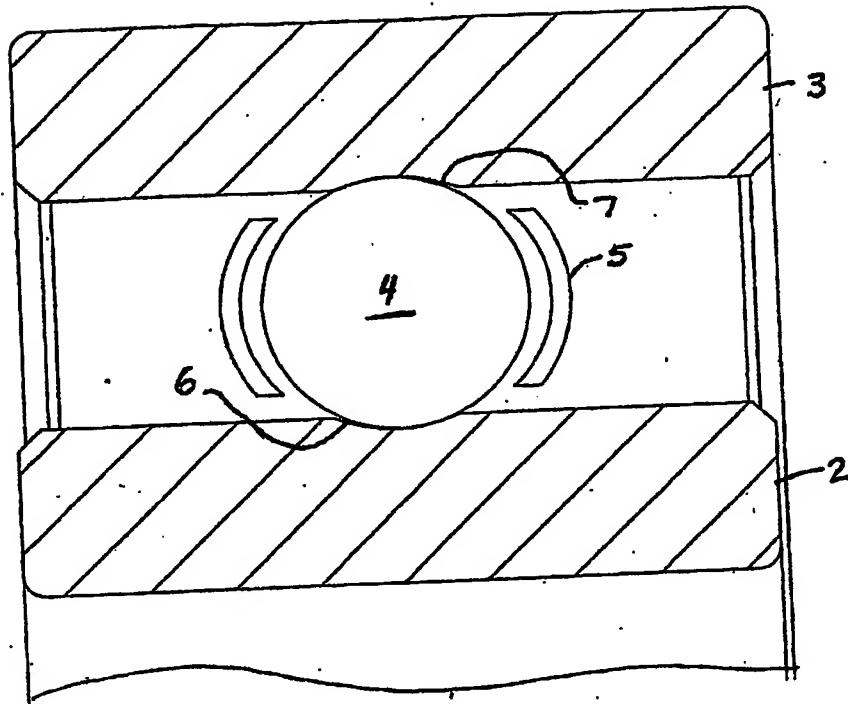
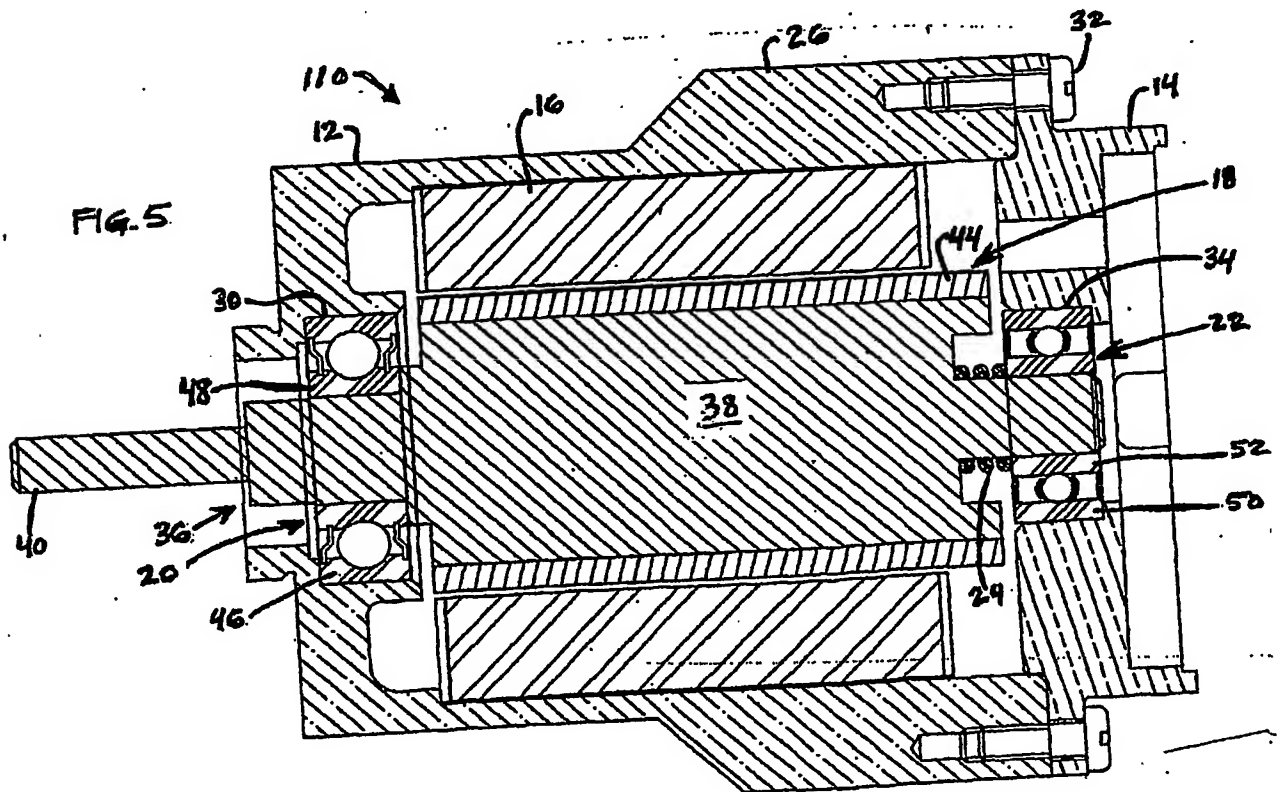
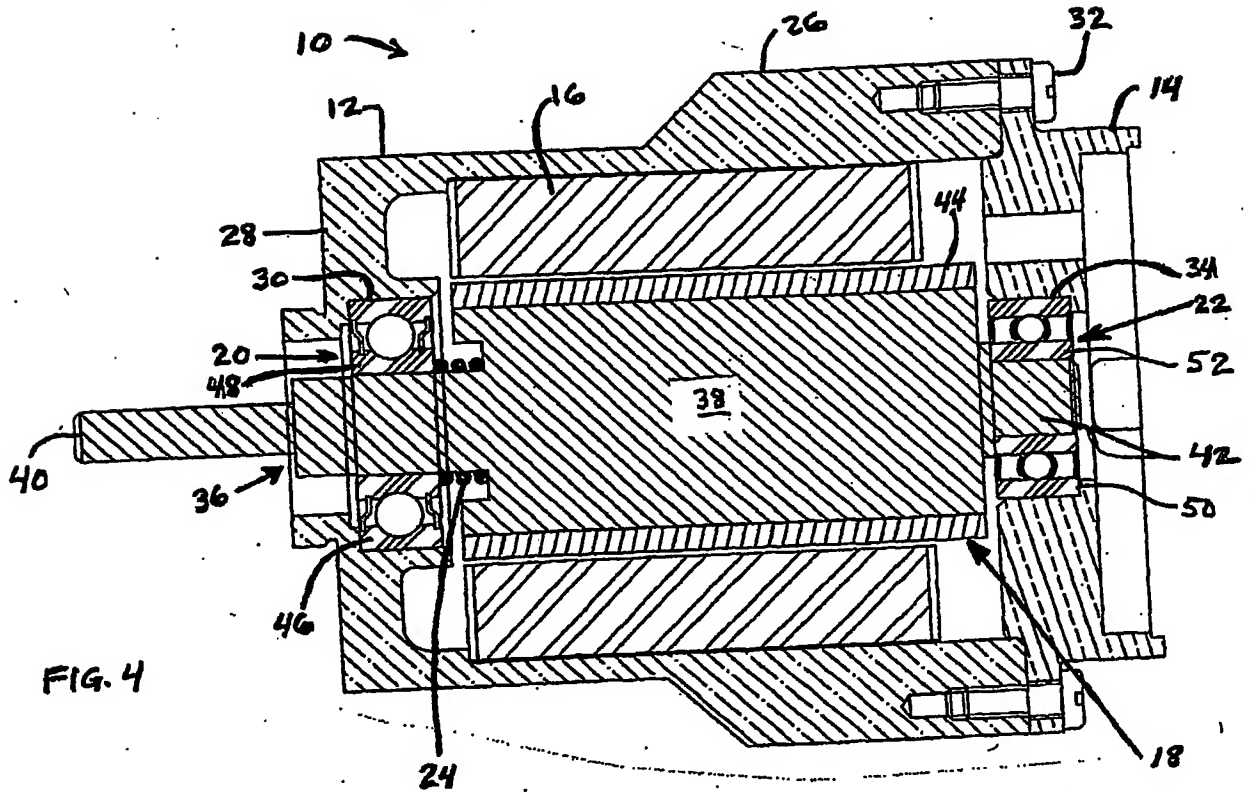
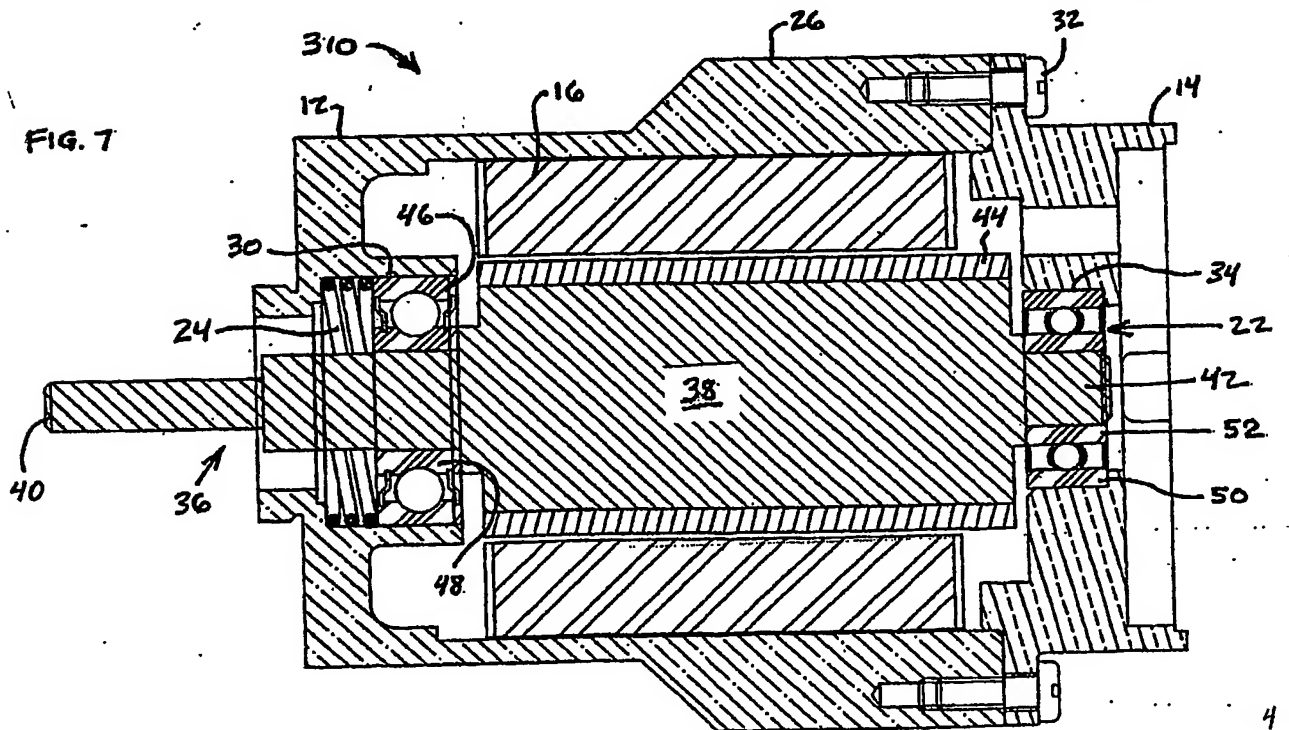
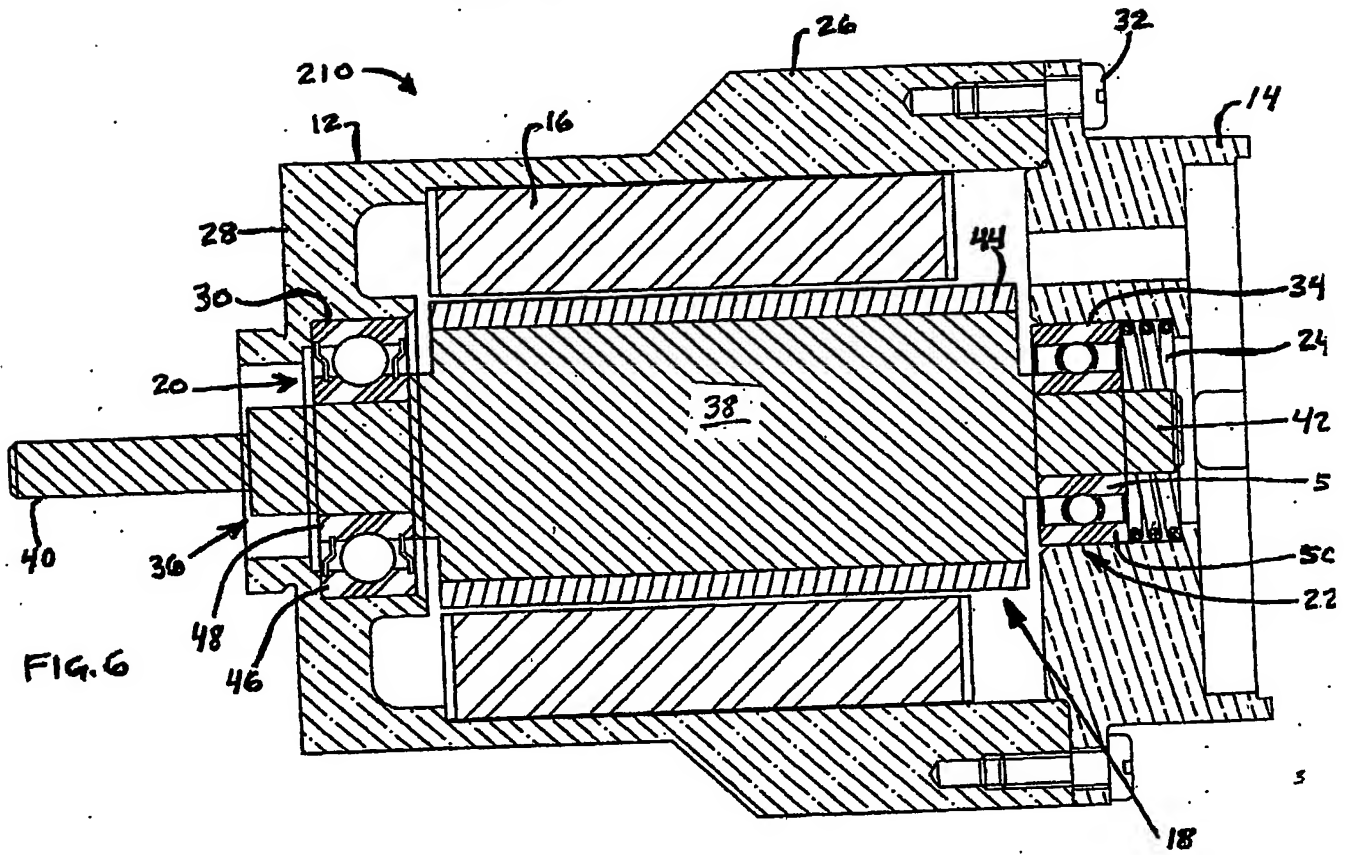


FIG. 3







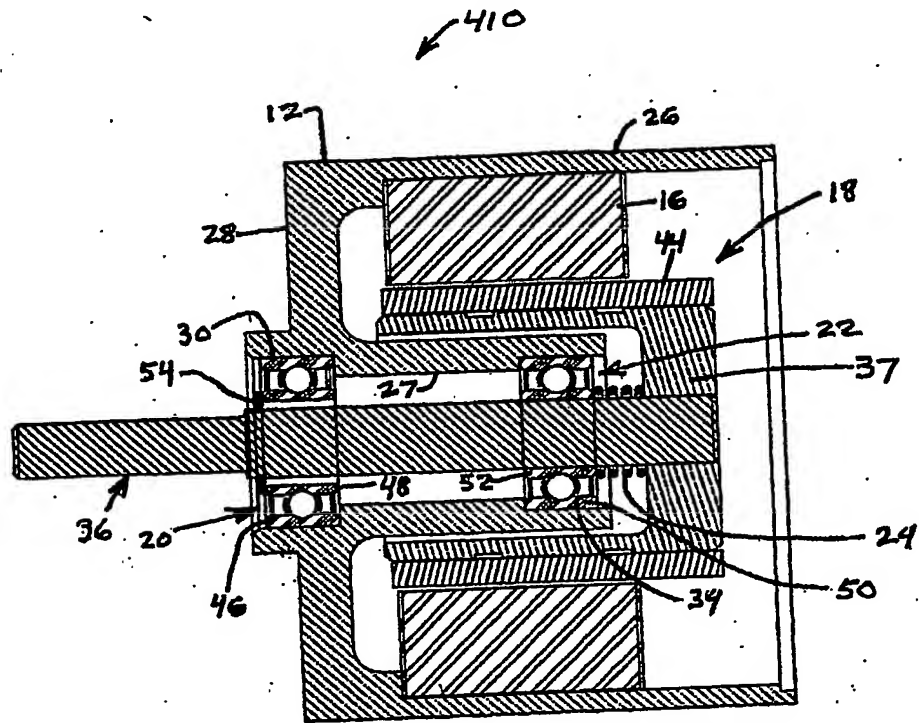


FIG. 8

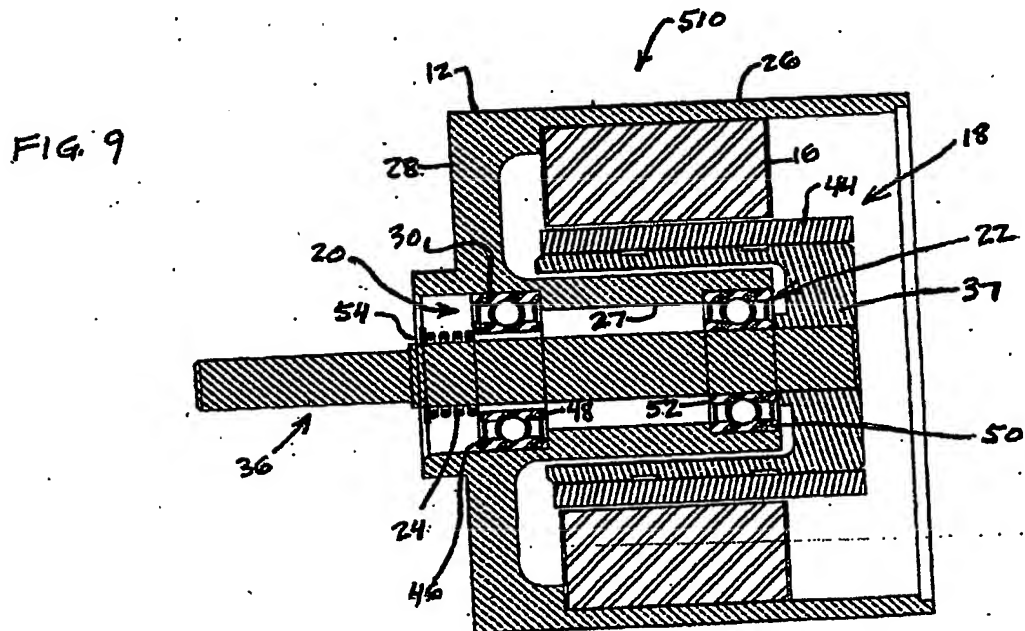


FIG. 9

